Marine Bird Populations in the Strait of Georgia; Comparison With the West Coast of Vancouver Island

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MARINE BIRD POPULATIONS IN THE STRAIT OF GEORGIA; COMPARISON WITH THE WEST COAST OF VANCOUVER ISLAND

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ABSTRACT

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Marine bird populations in the Strait of Georgia were examined and compared with those on the west coast of Vancouver Island. Four species breed in substantial numbers on islands in the Strait: the Glaucous-winged Gull (Larus glaucescens), Pigeon Guillemot (Cepphus columba), Pelagic Cormorant (Phalacrocorax pelagicus) and Double-crested Cormorant (P. auritus). Except for the Double-crested Cormorant, those species, as well as the Common Murre (Uria aalge), Rhinoceros Auklet (Cerorhinca monocerata), Tufted Puffin (Fratercula cirrhata), Cassin's Auklet (Ptychoramphus aleuticus), Fork-tailed (Oceanodroma furcata) and Leach's Storm-Petrels (O. leucorhoa) and Brandt's Cormorant (Phalacrocorax penicillatus) nest on the west coast of Vancouver Island. The greater variety of breeding birds on the west coast has been ascribed to suitable nesting conditions (Common Murres, Rhinoceros Auklets, Tufted Puffins, Cassin's Auklets and Storm-Petrels), as well as availability of food in the form of copepods (Cassin's Auklets) and a rich plankton supply over the shelf break (Storm-Petrels).

Pelagic populations in the Strait of Georgia are impoverished compared to those on the outer continental shelf, but the wintering marine bird fauna in the sheltered waters of the Strait is more diversified and abundant than on the west coast. In the Strait, there are large wintering populations of Western Grebes (Aechmophorus occidentalis) in the sheltered Gulf Islands, Barrow's Goldeneyes (Bucephala islandica) in the fjords, and hundreds of thousands of dabbling ducks utilizing the Fraser Delta estuary. Many piscivorous birds are attracted to the Strait's sheltered waters because of an influx of herring in winter. Of all birds, diving ducks are most numerous perhaps because of availability of molluscs, crustaceans and herring eggs in the shallow and sheltered waters of the Strait.

Key words: marine birds, Strait of Georgia.

ABSTRAIT

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Les populations d'oiseaux marins dans le détroit de Georgia furent examinées et comparées à celles de la côte ouest de l'île Vancouver. Quatre espèces se reproduisent en nombre substantiel sur les îles du détroit: le Goéland à ailes glauques (Larus glaucescens), le Guillemot du Pacifique (Cepphus columba), le Cormoran pélagique (Phalacrocorax pelagicus) et le Cormoran à aigrettes (P. auritus). A l'exception du Cormoran à aigrettes, ces espèces, ainsi que la Marmette commune (Uria aalge), l'Alque à bec cornu (Cerorhinca monocerata), le Marcareux huppé (Fratercula cirrhata), l'Alque de Cassin (Ptychoramphus aleuticus), le Pétrel à queue fourchue (Oceanodroma furcata), le Pétrel cul-blanc (O. leucorhoa), et le Cormoran de Brandt (Phalacrocorax penicillatus), se nichent sur la côte ouest de l'île Vancouver. On a attribué la grande variété d'oiseaux procréateurs sur la côte ouest au fait que les conditions y sont particulièrement adaptées pour se nicher (les Marmettes communes, les Alques à bec cornu, les Macareux huppés, les Alques de Cassin et les Pétrels cul-blanc et à queue fourchue); la nourriture, dans la forme de copépodes, y est disponible (les Alques de Cassin); et il y a une riche fourniture de plancton sur la cassure de la corniche (les Pétrels cul-blanc et à queue fourchue).

Les populations pélagiques dans le détroit de Georgia sont appauvries comparées à celles qu'on trouve sur l'extérieur de la corniche continentale; mais la faune d'oiseaux marins que hiverne dans les eaux protégés du détroit est plus diversifiée et abondante que sur la côte ouest. Dans le détroit, il y a de larges populations hivernantes de Grèbes de l'Ouest (Aechmophores occidentalis) habitant les îles du Golfe qui sont abritées, des Garrots de Barrow (Bucephala islandica) dans les fjords, et des centaines de mille de canards pataugeurs utilisant l'estuaire du delta Fraser. Beaucoup d'oiseaux piscivores sont attirés par les eaux protégés du détroit parce qu'il y a un afflux de harengs en hiver. De tous les oiseaux, les canards plongeurs sont les plus nombreux, peut-être a cause de la disponibilité de mollusques, crustacés et oeufs de hareng dans les eaux relativement peu profondes et protégés du détroit.

Mot-clés: oiseaux marins, le détroit de Georgia.

INTRODUCTION

The Strait of Georgia is a sheltered sea along the North American west coast with one main entrance to the Pacific, the Strait of Juan de Fuca to the south, and the more restricted Johnstone Strait to the north. The Strait's waters can be divided into pelagic and coastal regions reflecting different bird use; the latter consisting of estuarine, exposed and sheltered waters, and fjords.

Marine bird populations in the Strait vary over time and consist of breeding and wintering species. The breeding population is present from May to September. The winter population is composed of birds which remain after breeding and those which visit the Strait from August to May.

The objectives of this review are to delineate the breeding and wintering marine bird populations; to establish their food resources and habitat preferences; and to determine if the marine bird composition in the Strait of Georgia differs from that on the outer coast at similar latitudes.

Drent and Guiguet (1961) provided the first serious review of breeding seabird colonies in British Columbia. The British Columbia Provincial Museum prepared a wall map of seabird colonies of the Vancouver Island area (Campbell 1976). Vermeer et al. (1983) recently updated the information on breeding populations and provided the first overview on distribution and densities of birds at sea along the coast, including those in the Strait of Georgia. Most of the data on breeding and wintering birds in the Strait is from the latter source and from recent surveys by the author in the Gulf Island region. Food data of marine birds in the Strait of Georgia is from various sources (Table 2) and unpublished information by the author.

METHODS

Marine bird censuses were conducted in the Strait of Georgia on board a fishing boat and hydrographic vessel in March, April and November 1977. In addition, bimonthly surveys were conducted in a small vessel of some areas of the Gulf Islands and neighbouring southern Vancouver Island, from September 1977 to mid-May 1978. Birds in the winter were also counted from ferry boats travelling across the southern Strait of Georgia from Swartz Bay on Vancouver Island to Tsawwassen on the mainland.

Marine birds are defined in this paper as birds found on coastal and pelagic waters. Shorebirds have been omitted because, except for phalaropes, they are not found on the water.

RESULTS AND DISCUSSION

1. Breeding birds

The Glaucous-winged Gull (Larus glaucescens), the Pelagic Cormorant (Phalacrocorax pelagicus), the Double-crested Cormorant (P. auritus), and the Pigeon Guillemot (Cepphus columba) nest in substantial numbers in colonies on islands, in the

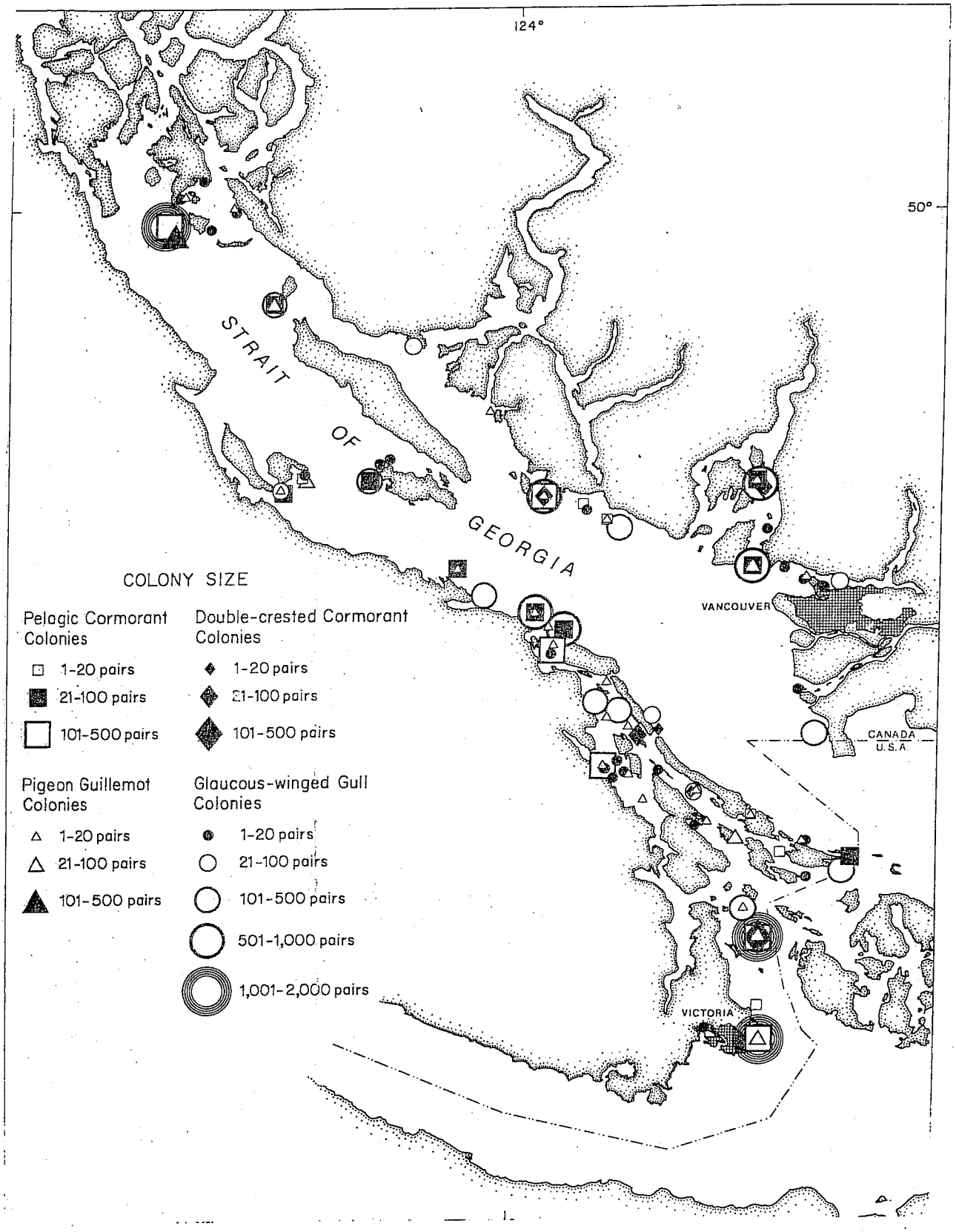

Figure 1 Breeding distribution of Pelagic Cormorants, Double-crested Cormorants, Glaucous-winged Gulls and Pigeon Guillemots in the Strait of Georgia (from Campbell 1976).

Strait of Georgia. Approximately 10,000 pairs of Glaucous-winged Gulls, 2,000 pairs of Pelagic Cormorants, 400 pairs of Double-crested Cormorants and 600 pairs of Pigeon Guillemots breed in the Strait of Georgia (Vermeer et al. 1983). Two pairs of Tufted Puffins (Fratercula cirrhata) are known to breed at Mandarte Island (Drent and Guiguet 1961). Little is known about the breeding populations of Marbled Murrelets (Brachyramphus marmoratum) as they breed solitarily in trees and on slopes where nests are difficult to find (Harris 1971, Sealy 1974, Binford et al. 1975, Simons, 1980).

The breeding colonies are found throughout the Strait except for Double-crested Cormorants which nest mostly in the southern regions (Fig. 1). The colonies are generally found in the vicinity of the feeding areas and in sites which are safe from mammalian predation. All four species forage in shallow waters or near shore (Drent 1965, Ward 1973, Robertson, 1974). Of those four species, the Glaucous-winged Gull exhibits greater flexibility in feeding habits as it scavenges on beaches and refuse dumps. Of the four species, the gull breeding population has increased 3.5 times between 1928 and 1974 (Butler et al. 1980), and this has been attributed to the increasing human population which leaves an abundant supply of refuse to the birds (Drent and Guiguet 1961, Vermeer 1963). Ward (1973) calculated that 50,000 Glaucous-winged Gulls alone use the Greater Vancouver garbage dumps during winter.

2. Wintering birds

a) Population densities

Boat surveys indicate that Western Grebes (Aechmophorus occidentalis), Surf Scoters (Melanitta perspicillata), Barrow's Goldeneye (Bucephala islandica), Greater Scaup (Aythya marila) and Glaucous-winged Gulls were the most numerous birds along the Strait of Georgia coastline and in inlets during the spring of 1977 (Fig. 2). Western Grebes, Surf Scoters and Barrow's Goldeneye predominated in autumn. Western Grebes had their highest densities in the sheltered waters of the Gulf Islands and Barrow's Goldeneyes occurred mostly in the mainland fjords. Greater Scaup were chiefly observed in spring on the east coast of Vancouver Island. Surf Scoters and Glaucous-winged Gulls were encountered in all regions.

b) Seasonal changes

Seasonal changes in marine bird populations were observed for south-eastern Vancouver Island and the adjacent Gulf Islands throughout autumn, winter and spring. Bird populations are diverse in those areas because of the large variety of feeding substrates and the presence of many sheltered bays, small estuaries, and narrow passageways between islands with strong tidal currents. Rapidly increasing numbers from September to November reflect autumn migration of birds into the Strait from northern, eastern and southern breeding grounds (Fig. 3). A peak in March reflects spring migration as well as birds moving into locations where herring spawned. Six main categories of marine birds were observed, namely loons, grebes, cormorants, waterfowl, gulls and alcids. Waterfowl predominated over all other categories from the end of September until March, while larids were most numerous at the end of summer.

The time of arrival, peak concentration and departure from the region is further indicated for the most prominent species in Fig. 4. Arctic Loons (Gavia arctica), most abundant of all loons, arrived in November, and peaked in January. A minor peak in April reflected incoming spring migrants. Western Grebes occurred in

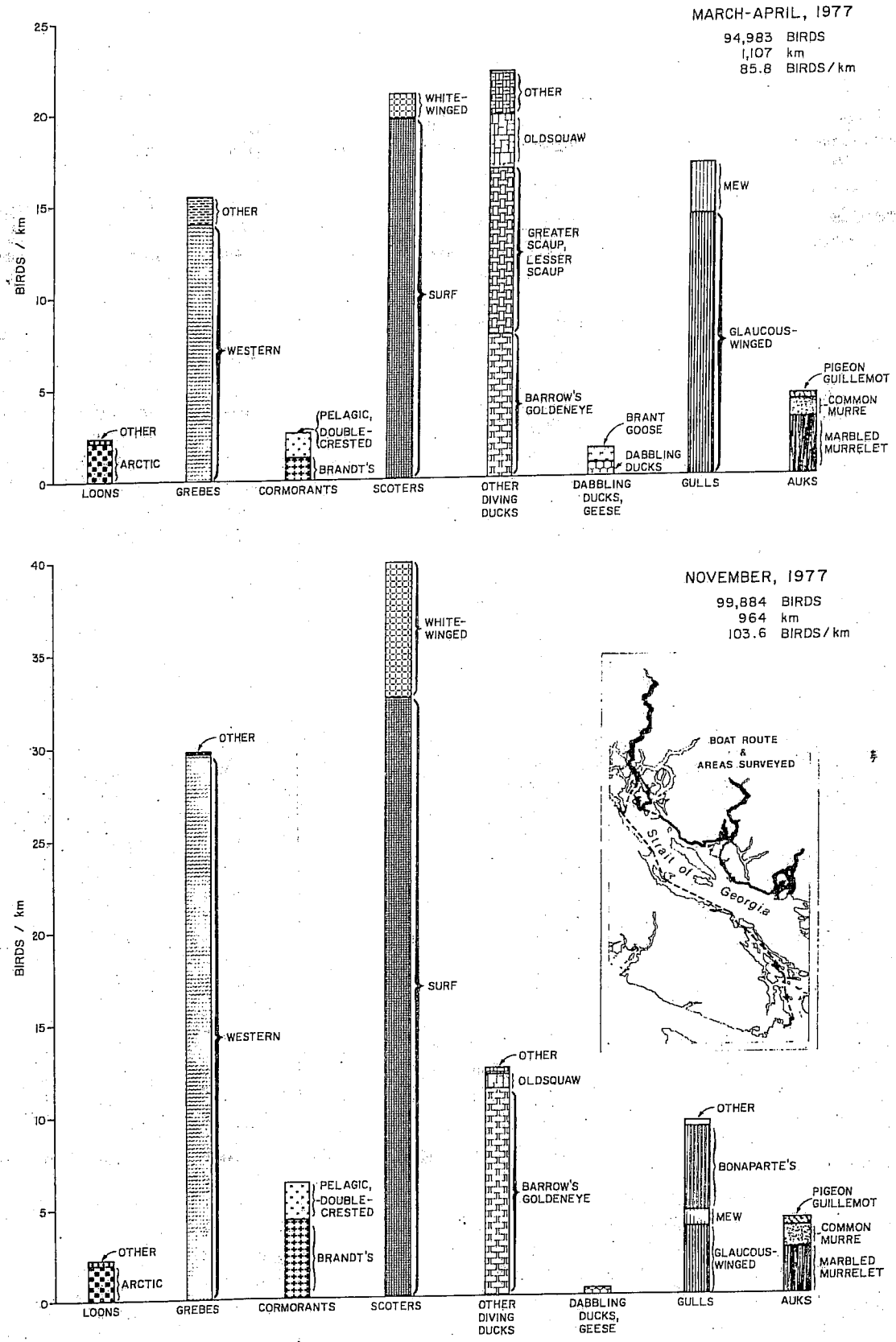

Figure 2 Marine bird densities in the Strait of Georgia and adjacent inlets as observed by boat, March-April and November, 1977 (from Vermeer 1981).

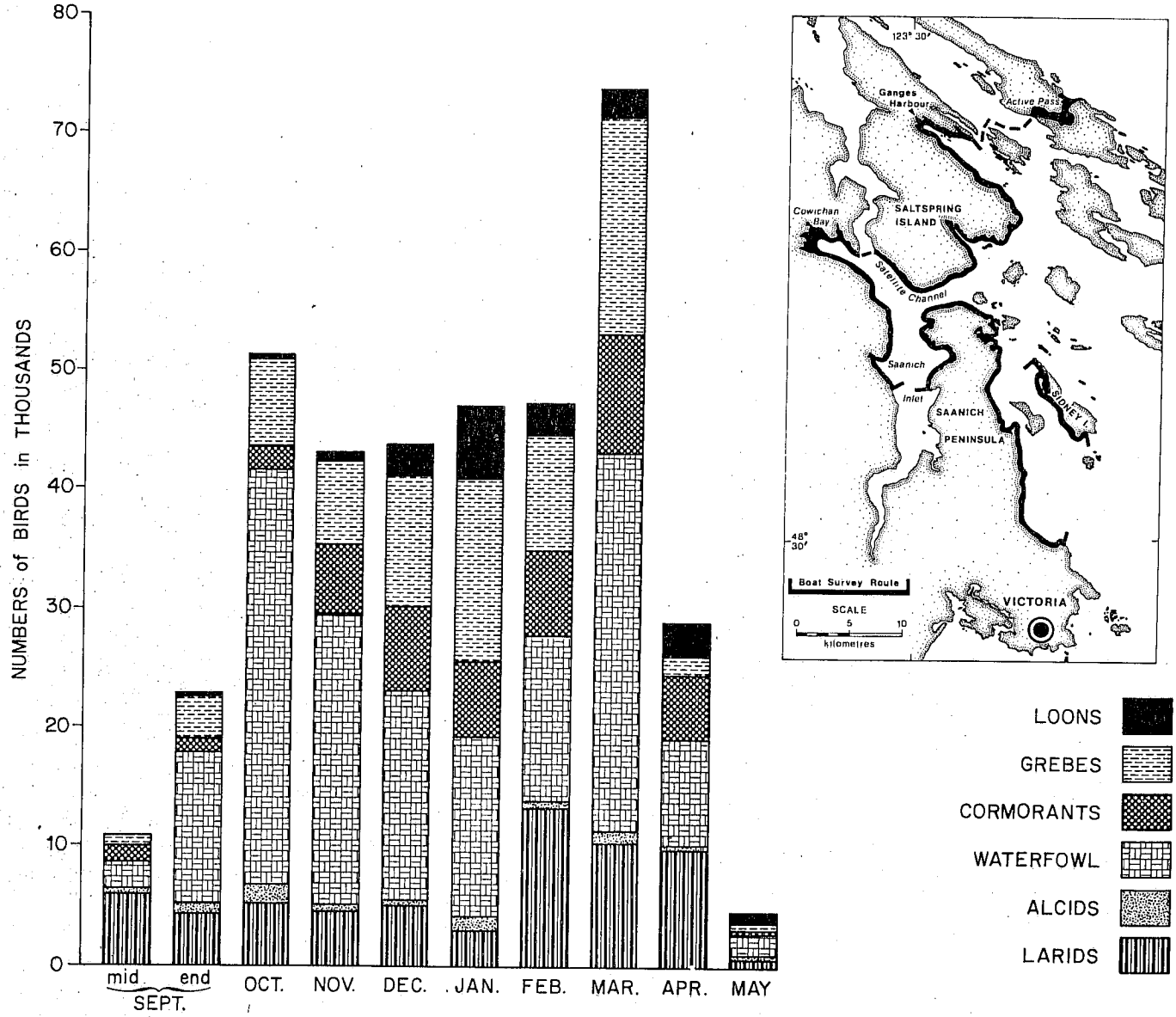

Figure 3 Marine bird fluctuations along 132 km of southeastern Vancouver Island and adjacent Gulf Island shorelines as observed during boat surveys, September 1977 to May 1978.

high densities from December to March, while Horned Grebes (Podiceps auritus) were most numerous in autumn. Brandt's Cormorant (Phalacrocorax penicillatus), the most numerous cormorant, utilized southern British Columbia's sheltered waters from November to April. Those cormorants show reverse migration in that they migrate north in autumn (Vermeer 1977).

Of the dabbling ducks, the American Wigeon (Anas americana) occurred in greatest concentrations along estuarine shores in autumn. Bay ducks arrived later than wigeons. Greater Scaup were numerous from October to March. Of the three Bucephala species, the Bufflehead (B. clangula) was most numerous, while the Common Goldeneye (B. clangula) and Barrow's Goldeneye were among the last migrants to arrive in the Gulf Islands. The Common Goldeneye far outnumbered the Barrow's Goldeneye. Surf Scoters and White-winged Scoters (Melanitta fusca) were the most numerous sea-ducks and peaked in October (Fig. 4).

Of the gulls, Glaucous-winged Gulls had the highest densities. Both Glaucous-winged and Mew Gulls (Larus canus) peaked in February and March. The Bonaparte's Gull (Larus philadelphia) arrived from northern breeding grounds in August. Their numbers declined in December when they migrated farther south, but returned by the end of March on their way northward.

Of the alcids, Common Murres (Uria aalge) were abundant in the Strait of Georgia from September to March. In April, they migrated to the outer west coast. Pigeon Guillemots occurred in highest densities in the Strait in autumn.

c) Bird use and habitat

Bird species vary according to habitat. In crossing the Strait of Georgia by ferry boat from Swartz Bay to Tsawwassen, one passes through four distinct habitats with different bird utilization (Table 1). They are the sheltered waters of the Gulf Islands, Active Pass with its strong tidal action, the exposed and pelagic waters of the Strait and the mudflats of Tsawwassen jetty.

Western Grebes were the principal species in the Gulf Islands as they prefer quiet waters where food abounds.

Arctic Loons, Brandt's Cormorants, Glaucous-winged Gulls, Mew Gulls and Common Murres were most numerous in Active Pass. The high bird density in Active Pass undoubtedly relates to strong tidal action, which causes upwelling of nutrients on which prey organisms feed.

In the exposed and pelagic waters of the Strait there were relatively few birds. Robertson (1977) also found low bird densities in the pelagic zone of the Strait and related this to an absence of herring. He also suggested that the discharge of the Fraser River, which creates a highly turbid layer of surface water, may limit the effectiveness of avian predators.

Dabbling and diving ducks were numerous along the Tsawwassen jetty. The mudflats of the Fraser Delta foreshore on which the Tsawwassen jetty is located, are known for their wintering population of hundreds of thousands of ducks which stage and feed in those areas (Vermeer and Levings 1977).

Two other major habitats in the Strait are the shallow broad banks of the central east coast of Vancouver Island and the fjords which enter the Strait from the

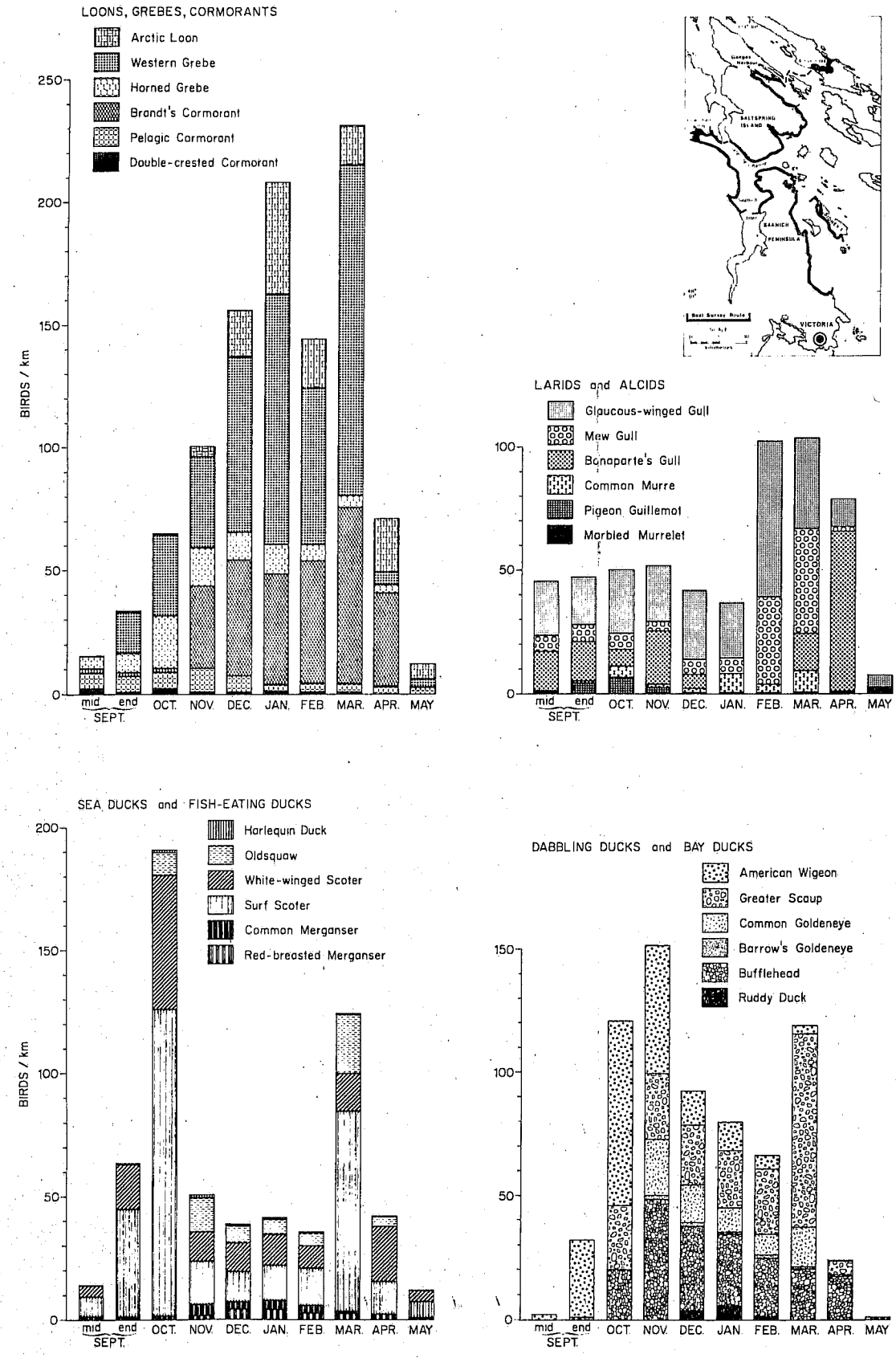

Figure 4 Individual species densities (bird/km) along 132 km of southeastern Vancouver Island and adjacent Gulf Island shorelines as observed during boat surveys, September 1977 to May 1978.

Table 1. Comparison of average bird densities (birds/km) along Swartz Bay - Tsawwassen ferry route based on surveys from ferry boat and by car along Tsawwassen jetty, 7:00-9:00 am, February 16, 23 and March 1, 1979.

Location	Loons	Grebes	Cormorants	Dabbling ducks	Diving ducks	Gulls	Alcids
Swartz Bay to Active Pass (20km) (Gulf Islands)	0.6	11.9[a]	8.7	-	1.2	15.6	3.1
Active Pass (plus east and west entrances, 8km)	93.9[b]	0.1	482.1[c]	-	16.0	120.4[d]	28.0
Active Pass to Tsawwassen terminal (17km) (Pelagic waters)	0.4	-	-	-	0.2	0.9	0.6
Tsawwassen jetty (2.8km) (Mudflats)	1.1	7.5	17.1	908.9[f]	546.1[g]	85.4[d]	2.5

[a] Mostly Western Grebes

[b] Mostly Arctic Loons

[c] Mostly Brandt's Cormorants

[d] Mostly Glaucous-winged and Mew Gulls

[e] Mostly Common Murres

[f] Mostly American Wigeon

[g] Mostly Greater Scaup

mainland. Tens of thousands of diving ducks occur in autumn as well as in spring over the banks of eastern Vancouver Island. The high density of diving ducks there may relate to the accessibility of prey such as molluscs, crustaceans and herring eggs. Barrow's Goldeneyes and Surf Scoters were most numerous in the fjords where they chiefly fed on mussels attached to the fjord walls (Fig. 5, Vermeer 1981a). Bottom-feeding ducks were much less common; perhaps since the fjords are too deep to suit their foraging behaviour.

d) The importance of herring

Herring is one of the main staples of Arctic Loons, Western Grebes, Brandt's Cormorants, gulls and alcids (Table 2). Herring migrate in autumn from the outer west coast into the Strait of Juan de Fuca. The herring disperse from there into the Strait of Georgia and spawn in its sheltered waters in February and March, after which they depart. Piscivorous birds enter the Strait of Georgia from various directions and their seasonal fluctuations appear to reflect corresponding herring abundance and movements. For instance, Brandt's Cormorants fly from the U.S. west coast and mainly arrive in large numbers in the Strait of Georgia in November (Vermeer 1977). The cormorants leave again at the end of April (Fig. 4). Common Murres fly and swim into the Strait of Juan de Fuca from Oregon in late summer and autumn (D.A. Manuwal pers. comm.). They appear to peak in the Strait of Juan de Fuca in September as 240,000 murres were then observed in open waters in 1978 (Manuwal et al. 1979). From the Strait of Juan de Fuca the murres disperse into the Strait of Georgia and remain until April (author, pers. observ. Fig. 4). Western Grebes arrive from their interior nesting colonies in early autumn. Thereafter, their numbers increase during winter before departing from the Strait shortly after the spawning of herring in March (Fig. 4).

Herring spawn constitutes a major food for piscivorous as well as non-piscivorous birds in the Strait for approximately three weeks in March. For example, during the herring spawning season (March 1978), bird numbers in Ganges Harbour increased from 2,000 in mid-February to 56,000 by mid-March and after that declined to 500 by the end of that month (Vermeer 1981a). Most numerous were Brandt's Cormorants feeding on spawning herring, Western Grebes, Glaucous-winged and Mew Gulls feeding on both herring and eggs, and Surf Scoters, Greater Scaup and Oldsquaws (Clangula hyemalis) feeding on herring eggs. The above example indicates that when a food suddenly becomes available in a large quantity, many bird species temporarily abandon their staples and converge on that resource. Highest densities of Western Grebes, Brandt's Cormorants, Greater Scaup, Oldsquaws, Glaucous-winged and Mew Gulls were observed in the Gulf Islands just prior to and during the spawning of herring than in any other time of the year indicating the importance of those fish to the birds as a source of energy during migration and prior to breeding (Fig. 4). Herring is not always an abundant commodity and their stocks were in decline from 1940 to 1960, but have recovered since (Humphreys and Webb 1970).

e) Other foods

Molluscs and crustaceans are important staples for most diving ducks (Table 2). Some ducks have one main staple food. The Surf Scoter and the Barrow's Goldeneye feed mainly on blue mussels (Mytilus edulis). The largest duck, the White-winged Scoter, has two staples, namely clams and snails (Vermeer and Bourne 1983). Crustaceans are prominent in Bufflehead and Common Goldeneye diets, as well as in those of Horned Grebe, Mew Gull and Pigeon Guillemot (Table 2).

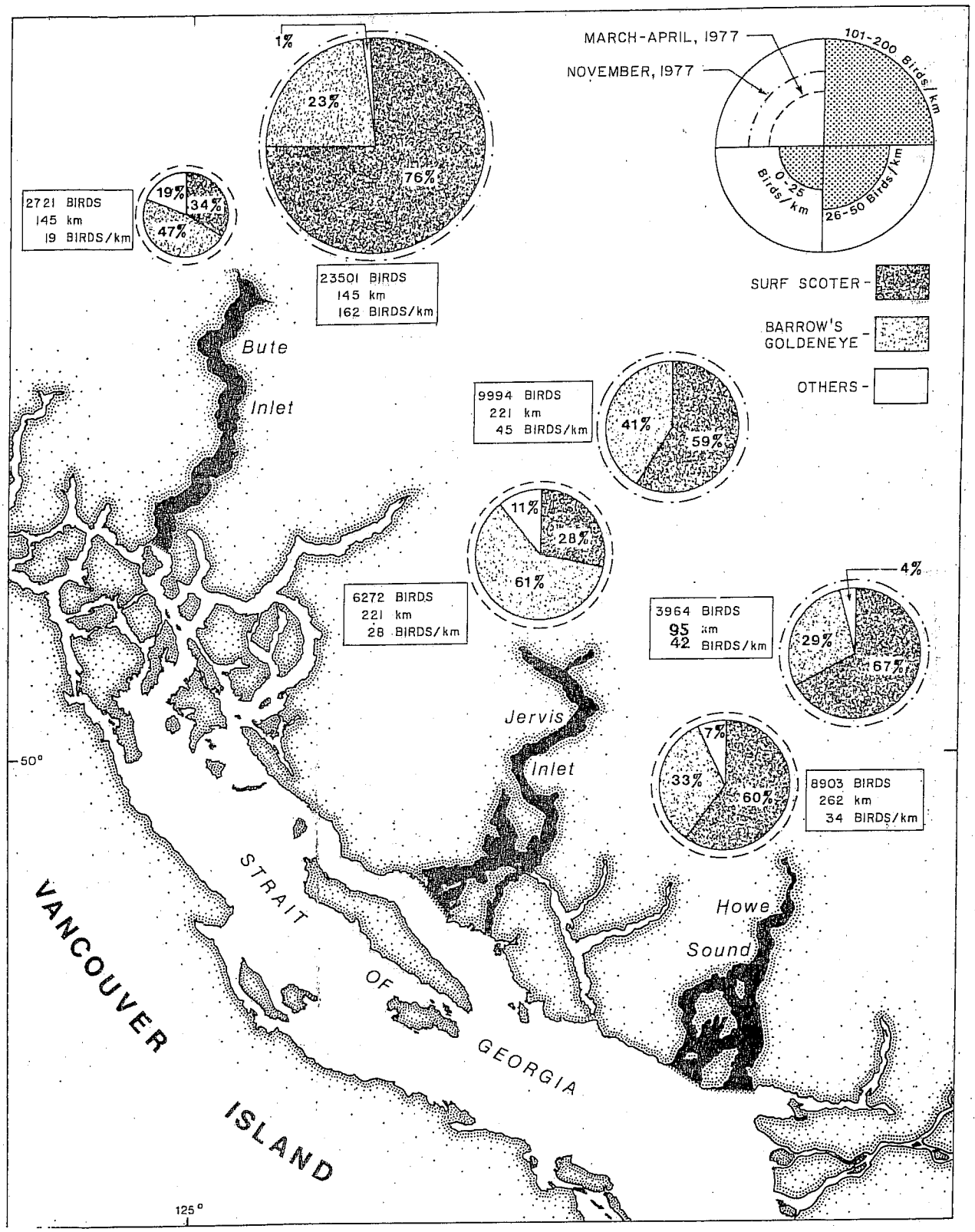

Figure 5 Duck numbers and densities in three fjord systems: Bute Inlet, Jervis Inlet and Howe Sound, March-April and November, 1977 as observed by boat (from Vermeer 1981).

Table 2. Food of principal wintering birds in the Strait of Georgia.

Bird species	Chief food item	Source
Loons, grebes, cormorants		
Arctic Loon	Herring	Robertson 1973
Western Grebe	Herring and herring eggs	Phillips and Carter 1957, This paper[a]
Horned Grebe	Shrimp	This paper[a]
Brant's Cormorant	Herring	Robertson 1973
Pelagic Cormorant	Herring, shrimp	Munro and Clemens 1931
Dabbling Ducks		
American Wigeon	Ulva, Enteromorpha sp.	Vermeer and Levings 1977
Bay ducks		
Bufflehead	Snails, shrimp	Vermeer 1982
Common Goldeneye	Crustaceans, herring eggs	Vermeer 1982
Barrow's Goldeneye	Mussels	Vermeer 1981a, 1982
Greater Scaup	Snails, algae, vascular plants, herring eggs	Munro 1941, Vermeer and Levings 1977,
Sea ducks		
Surf Scoter	Mussels, herring eggs	Vermeer 1981a
White-winged Scoter	Clams, snails	Vermeer and Bourne 1983
Black Scoter	Mussels	Vermeer and Bourne 1983
Oldsquaw	Macoma clams	Vermeer and Levings 1977
Harlequin Duck	Snails and limpets, fish eggs, crabs and chitons	Vermeer 1983b
Fish-eating ducks		
Common Merganser	Sculpins	Munro and Clemens 1937
Red-breasted Merganser	Sculpins, herring	Munro and Clemens 1939
Gulls		
Glaucous-winged Gull	Human refuse, herring, intertidal organisms	Munro and Clemens 1931, Robertson 1973, this paper[a]
Mew Gull	Herring and eggs, mussels, amphipods, isopods	Munro and Clemens 1931, This paper[a]
Bonaparte's Gull[b]	Fish, insects, plankton	This paper[a]
Auks		
Common Murre	Herring	Munro and Clemens 1931, Robertson 1973
Marbled Murrelet	Larval fishes, mysids	Munro and Clemens 1931
Pigeon Guillemot	Fishes, crab, shrimp	Munro and Clemens 1931

[a] See Appendix

[b] Mostly a spring and autumn migrant

The Glaucous-winged Gull is a generalist as it scavenges for human refuse, combs beaches for intertidal organisms and feeds on fish schools. During the breeding season the gulls eat mostly human refuse, herring and blue mussels in the Strait of Georgia, and herring, Pacific sand lance (Ammodytes hexapterus), Pacific saüries (Cololabis saira), gooseneck barnacles (Pollicipes polymerus) and California mussels (Mytilus californicus) on the west coast of Vancouver Island (Vermeer 1983a). The gull foods reflect abundance and accessibility of prey items in the two regions.

Other generalists are the Mew Gull which feeds on fish, mussels, crustaceans and human refuse; and the Bonaparte's Gull which plunge dives for fish, hawks insects and picks up plankton at driftlines and in areas of upwelling.

3. Comparisons between the Strait of Georgia and outer coast

a) Breeding populations

More species nest on the west coast of Vancouver Island than in the Strait of Georgia (Table 3). The greater species diversity on the west coast reflects the presence of certain foods, feeding and nesting habitats which are scarce or absent in the Strait. The Cassin's Auklet (Ptychoramphus aleuticus) which is by far the most numerous breeding sea bird on the west coast, feeds mostly on plankton over the shelf break and seamounts during the breeding period (Vermeer 1981b, author unpublished. inform.). The Cassin's Auklet's main prey species is the copepod, Neocalanus cristatus, which is scarce or absent in the Strait of Georgia (J. Fulton pers. comm.). The Fork-tailed Storm-Petrel (Oceanodroma furcata) like the Cassin's Auklet, forages mostly over the shelf break (author, unpubl. inform.), while the Leach's Storm-Petrel (O. leucorhoa) feeds far offshore and in warm oceanic surface waters during summer (Martin and Myres 1969, author, unpubl. inform.). Lack of suitable nesting habitat for burrow nesters and the presence of numerous nesting Glaucous-winged Gulls in the Strait may limit species such as Rhinoceros Auklets, Tufted Puffins, Cassin's Auklets and Storm-Petrels (Vermeer 1979). Glaucous-winged Gulls can prey extensively on Storm-Petrels and small alcids (Trapp 1979) and have been observed to klepto-parasitize larger alcids (Vermeer 1979). Common Murres may not nest in the Strait of Georgia because of a lack of appropriate nesting conditions. Although there are a number of islands with suitable nesting cliffs in the Strait, the murres would be susceptible there to frequent human disturbance and perhaps to predation by mammals. River otters (Lutra canadensis) have been observed to prey on Glaucous-winged Gull colonies in the Strait of Georgia (Foottit and Butler 1977, Verbeek and Morgan 1978). Glaucous-winged Gulls are numerous both on the west coast and in the Strait, undoubtedly as their food supply has been enhanced by increased human activities (e.g. garbage disposal in the Strait and fishing on the west coast). Pelagic Cormorants and Pigeon Guillemots are inshore feeders and their breeding populations in the Strait do not differ much from those on the west coast. The Double-crested Cormorant is the only species in the Strait which does not nest on the west coast. However, no serious comparison can be made between the Strait and west coast for the Double-crested Cormorants as their populations are small and only occur in the southern portion of the Strait. Moreover, Double-crested Cormorants commonly breed on both the inner and outer coasts of Washington State (Manuwal and Campbell 1979).

b) Coastal wintering population

Aquatic bird species utilizing coastal waters in winter are more diversified in the Strait than on the west coast of Vancouver Island mostly as a result of the

Table 3. Comparison of breeding populations of marine birds in the Strait of Georgia and on the west coast of Vancouver Island, 1976-1980 (from Vermeer et al. 1983).

Species	Strait of Georgia		West Coast of Vancouver Island	
	No.	%	No.	%
Fork-tailed Storm Petrel	-	-	810	0.1
Leach's Storm-Petrel	-	-	26,400	3.0
Brandt's Cormorant	-	-	200	
Double-crested Cormorant	825	3.2	-	
Pelagic Cormorant	4,040	15.5	2,700	0.3
Glaucous-winged Gull	20,000	76.7	15,000	1.8
Common Murre	-	-	8,000	0.9
Pigeon Guillemot	1,200	4.6	1,470	0.2
Cassin's Auklet		-	720,000	85.3
Rhinoceros Auklet		-	33,600	3.9
Tufted Puffin	4	Trace	56,200	6.5
Total number of birds	26,069		864,380	

presence of extensive estuaries and sheltered habitat in the Strait. For example, dabbling ducks are most numerous on the Fraser Delta foreshore and Boundary Bay as the result of extensive tidal mudflats where the ducks rest and feed. Greatest concentrations of Western Grebes occur in the Gulf Islands apparently because of the presence of extensive sheltered waters, while Barrow's Goldeneyes predominate in mainland fjords.

c) Pelagic populations

Bird species in the pelagic waters of the Strait are similar to those found near shore, but species are fewer and densities are much lower than along shorelines. The pelagic bird fauna off the west coast of Vancouver Island differs from near shore assemblages as well as from that in the Strait of Georgia. On the narrow Continental Shelf one encounters fish-feeding Sooty Shearwaters (Puffinus griseus), and Rhinoceros Auklets, while on the shelf break both fish- and plankton-feeders are numerous. Predominantly fish-feeders are shearwaters, plankton- and fish-feeders are Cassin's Auklets, Ancient Murrelets (Synthliboramphus antiquus), Fork-tailed Storm-petrels, Black-footed Albatrosses (Diomedea nigripes) and Fulmars (Fulmarus glacialis). In far offshore and warmer waters, Leach's Storm-Petrels and Black-footed Albatrosses predominate. Populations of the above species are generally small or absent in the Strait. An exception are from 2,000 to 8,000 Ancient Murrelets feeding in turbulent waters during some winters near Victoria (R. Hay, and M.G. Shepard, pers. comm.).

CONCLUSION

A comparison of aquatic bird populations in the Strait with those on the west coast leads to the obvious question: "Is the aquatic bird fauna of the Strait unique?" From observations of populations in nesting colonies and in pelagic waters, the answer appears negative. There are few breeding species and the pelagic populations in the Strait are impoverished when compared to those on the west coast. But when one compares wintering shoreline populations the reply is affirmative. The Strait's shorelines are more diversified than those on the Vancouver Island west coast. The Strait is unique for the large Fraser Delta estuary with hundreds or thousands of wintering dabbling ducks. The broad and shallow shelf of the Vancouver Island east coast has high densities of diving ducks. The sheltered Gulf Islands contain the largest wintering populations of Western Grebes in British Columbia and have large flocks of piscivorous birds in tidally active passages. The largest known wintering populations of Barrow's Goldeneyes in the world appear to occur in British Columbia's mainland fjords (Vermeer 1982).

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Appendix Food obtained from wintering birds in the Strait of Georgia except for 10 Mew and 8 Bonaparte's Gulls from Alice Arm. Occurrence of food items, feathers and grit in birds in parentheses.

Birds	No. birds with food	Food Items	Location, time
Western Grebe	10	Herring (8), Herring eggs (6), Feathers (10)	Fraser Delta, January--February 1974
Horned Grebe	15	Heptacarpus sp. (2), Pandalus danae (6), Hippolyte clarki (1) Parathemisto sp. (1), Orchomonella sp. (1), Decapod fragments (2), Digested fish (5), Feathers (15)	Southern Saltspring Island, October 1978
Glaucous-winged Gull	16	Human refuse (7), Fish (1), Mytilus edulis (3), Upogebia pugettensis (5), Crangon sp. (1) Telmessus cheiragonis (4), Plant fragments (4), Grit (4)	Fraser Delta February 1978
Mew Gull	6	Herring (2), Feb (unid.) (1), Littorina sitkana (1), Mytilus edulis (1), Human refuse (1)	Southern Saltspring Island, October 1978
	3	Human refuse (2), Crangon sp. (2), Anisogammarus sp. (1), Ulva sp. (1)	Fraser Delta February 1974
	10	Mytilus edulis (3), Gnorisphaeroma oregonensis (3), Pentidotea wosnesenski (1), Ligia sp. (1), Anisogammaurs sp. (3)	Alice Arm August 1976
Bonaparte's Gull	13	Fish (8), Herring (5), Insects (4)	Southern Saltspring Island, October 1978
	4	Parathemisto pacifica (4), Thyssanoessa spinifera (3), Euphausia pacifica (2) Parathemisto pacifica (2), Vibilia propingua (1)	Active Pass March 1978
	8	Insects (5), Anisogammarus sp. (1), Gnorimosphaeroma oregonensis (1), Bivalve fragments (3), Snail (1), Algae (2)	Alice Arm August 1976